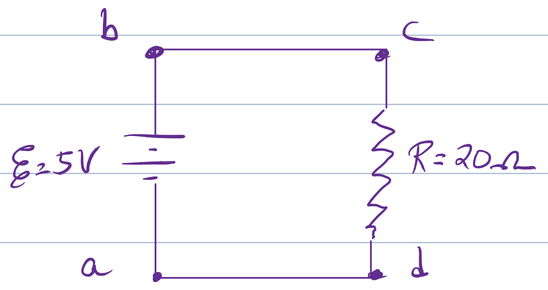
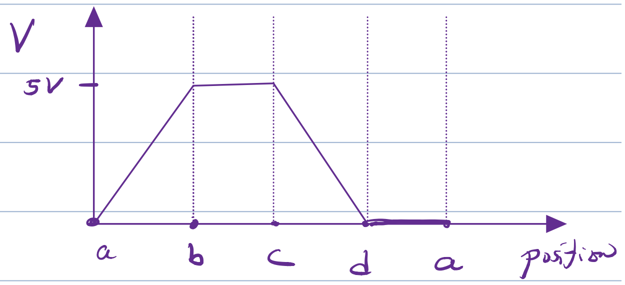
22.3 Batteries and emf (review)





Look at resistor and apply Ohm's Law

$\Delta V = IR$

$5V = I(20\Omega)$

$I = \dfrac{5V}{20\Omega} = 0.25A$

22.6 energy and power

In 1 second, how much energy did the battery supply? $\Delta U = q_0 \Delta V$

$\Delta V = 5V = 5\ J/C$

$q_0 = I \cdot \Delta t$

$q_0 = 0.25\ C/s \cdot 1s = 0.25C$

$\Delta U = (0.25C)(5\ J/C) = 1.25\ J$

What is the Power - the <u>rate</u> at which the battery supplied energy?

$$P = \frac{\Delta U}{\Delta t} = \frac{I \cdot \Delta t \cdot \Delta V}{\Delta t} = I \cdot \Delta V$$

$$P = \left(0.25 \frac{C}{s}\right) \cdot \left(5 \frac{J}{C}\right) = 1.25 \frac{J}{s} = 1.25\ W.$$

General Rule: $\boxed{P = I \cdot \Delta V}$

What happened to that energy? It was dissipated in the resistor

$P = I \cdot (-5V) = -1.25\ W$

This is called Joule Heating.

Alternate forms for a resistor:

use Ohm's Law $\Delta V = IR$, or $I = \Delta V / R$

$$P = I\cdot(\Delta V) = I\cdot(IR) = I^2R =$$

$$= \left(\frac{\Delta V}{R}\right)^2 \cdot R = \frac{(\Delta V)^2}{R}$$

$$P = I(\Delta V) = I^2R = \frac{(\Delta V)^2}{R}.$$

But the general rule is

$$P = I(\Delta V)$$

electrical safety: at a household 120V outlet capable of supplying 20A

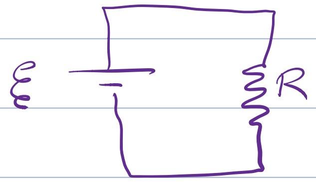
$$P_{max} = (20A)(120V) = 2400\,W \text{ - a lot!}$$

e.g. Toaster Oven $P = 1{,}000\,W$

$\mathcal{E} = \Delta V = 110\,V$

$R = ?$

$I = ?$



$$P = \mathcal{E} I \Rightarrow I = \frac{P}{\mathcal{E}} = \frac{1000W}{110V} = 9.09A$$

$$R = \frac{\Delta V}{I} = \frac{\mathcal{E}}{I} = \frac{110V}{9.09A} = 12.1\,\Omega$$

Power supplied by outlet:

$$P = \mathcal{E} I = (110\,V)(9.09\,A) = 1{,}000\ W$$

Power dissipated by toaster

$$P = I^2 R = (9.09\,A)^2 (12.1\,\Omega) = 1{,}000\ W$$

Example: ch22-nichrome-wire.pdf.